THE DYNAMICAL EMERGENCE OF SYSTEMS IN EARLY BILINGUAL DEVELOPMENT: THE ROLES OF MODULARITY AND MATURATION*

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WORK TO STILL BE DONE:

1) Discuss Radical construction (Deuchar new)
2) Discuss constraints of model and how it can be falsified

ABSTRACT

Advances in computational linguistic research and brain imaging technology obligate us to revisit the debate concerning whether emerging bilingual linguistic knowledge is best represented as either two separate grammatical systems or as a unitary system from the onset of language development. The dominance of the previous approaches stems from emphasis on a single level of linguistic analyses (e.g., phonological, morphosyntactic, etc.). We contend that the consideration of the full range of data (e.g., phonetic, phonological, morphosyntactic ,and semantic) suggests a third account, which we term dynamical modularity, as an attractive alternative for approaching theoretical questions of early bilingual grammatical organization. We begin by specifying the nature of the "linguistic system architecture," making particularly explicit what an initial architecture entails. In the spirit of Marr's (1982) hierarchical representation of the visual system, we then introduce a three-tier model as a computational-formalist description of how each discrete linguistic module comes to be fully operational over time, based on the processing of input and biological/maturational factors. We subsequently demonstrate that the model aptly accounts for the unfolding bilingual linguistic competence in infant language learners, and we support these claims with substantive empirical evidence.

INTRODUCTION

Most theoretical perspectives advanced on language representation in the infant bilingual mind/brain make similar claims with respect to the linguistic cognitive architecture involved in the development of the child's grammars. Virtually all parties agree that (a) in its initial (pre-linguistic) state, the architecture constitutes a singular unit of some sort; and also (b), that the bilingual steady phase reflects the differentiation of two separate linguistic systems at some level of representation. Widespread disagreement has continued to hinge, however, upon questions concerning the point at which the nascent structure transforms into two fully-operational grammatical systems. In this paper, we argue that while the "early or late dual-systems" inquiry may be valid, such a concentrated focus may actually be premature. In the large body of

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research on bilingual L1 acquisition to date, very little attention has been devoted to understanding the underlying components comprising the bilingual L1 architecture, or to the nature of the internal changes in the architecture that result in the emergence of different grammars (or minimally, different derivational patterns). In order for formal analyses on linguistic organization in the bilingual mind/brain to have merit, they must be founded on principled conceptual descriptions of the linguistic system typology in the context of bilingual language learning.

The work presented in this current paper has the goals of both clarifying what the bilingual linguistic system entails, by delineating the initial state of the mental linguistic architecture and its resultant internal computations, and also of demonstrating that when examined at a modular level of representation, the core features and patterns found in the emerging bilingual system are common to many other biological and brain systems. With respect to the human bilingual potential, these are necessary and interesting aims to make explicit. As with similar systems, it should become possible to extract information concerning individual external and internal components involved in the emerging bilingual system, and to make definite predictions as to the nature of and the interactions between those components.

The remainder of the paper proceeds as follows: in Section One, we sketch out the properties both of the initial and final states of the human language faculty. We link our claims to overarching notions found in theories of Universal Grammar (Chomsky 1965, 1981, 1993, 1995), modularity (Fodor 1983, Jackendoff 1997, 2002), and linguistic maturation (Wexler 1990a, 1999). Section Two takes as its point of departure this conception of linguistic system and then attempts to make the hypothesis of emerging bilingualism as precise as possible. We thus outline a part-whole model of bilingual language information structure, in the spirit of

Jackendoff's (1997) tripartite parallel architecture for (monolingual) grammar and Marr's (1982) hierarchical conception of the visual system, in which visual information is encoded in one area, but is subsequently influenced by its interfaces with various other brain areas. Section Three addresses further implications for a dynamical modular conception of bilingual grammar representation, while Section Four offers final concluding remarks.

1.0 OVERVIEW: THE HUMAN LANGUAGE FACULTY

1.1. THE NOTION OF (LINGUISTIC) SYSTEM

Certain concepts are often considered so obvious that close scrutiny of these constructs fails to take place. As regards the discussion of bilingual grammatical acquisition, however, the notion of a formal "system" has never been well enough defined to sustain the level of argumentation that has come to be associated with it. Since any analysis of language development requires a clear understanding of what formally constitutes a linguistic system, let us begin by examining some definitions culled from the physical and engineering sciences: "i) a regularly interacting or interdependent group of items which form a unified whole; ii) an assemblage of substances that is in equilibrium; iii) a body that is considered a functional unit, organized as a network especially for distributing information or for serving a common purpose."[1]

These same notions of system carry over very well to a characterization of the state of adult linguistic competence. 'System' in the linguistic sense can thus be defined as the output of an individual cognitive unit reflecting a unified, steady-state relationship between sound, form, and meaning. Now, when viewed from a developmental perspective, how applicable is this working definition? A logical assumption is that the very young child does not automatically begin the

language learning task with the ability to manipulate this 'adult' type of intact linguistic system, as s/he must first acquire an adequate number of separate items that designate sound, form, and meaning. Preliminary linguistic motivation for this assumption, in fact, comes from Cruttenden (1981) in the form of experimental evidence for modular developmental phases in the monolingual child's acquisition of semantics, morphology/syntax, and phonology. When a critical mass of such material has been acquired, it then seems to trigger an innate cognitive response to attempt to group the items and discover relationships among them (cf. Peters 1986). Slobin (1985a) likewise gives credence to the view that the child accumulates non-unified linguistic knowledge initially, positing that these units come to be systematized via strategies known as Operating Principles. For bilinguals, the assumption is strengthened based on empirical findings compiled from various sources and noted in Deuchar & Quay (2000). Deuchar & Quay conclude that many features corresponding to a particular grammar seem to be as yet unorganized into a sufficiently language-specific system, based on the data of infant bilinguals. In terms of the present study on the dynamically-modular emergence of the bilingual system, these claims are all the more compelling, since the evidence suggests that some general small-scale unification of components occurs early on, such as between syntax-semantics or syntax-phonology. Since most previous research has focused on an isolated aspect of the child's grammatical development, such as solely on the syntax or phonology to the exclusion of other areas, these studies may have mistakenly reported on a surface effect which gives the appearance of either two differentiated systems of grammars or of one fused system, even while system-building was still in progress. For these reasons, the point of departure for this research must be on how the bilingual linguistic system begins to emerge in the first place.

[1] See John Holland (1998) for an in-depth discussion concerning the nature of "systems."

1.2. ARCHITECTURE

Within the generative framework, the language faculty is commonly held to be an autonomous unit which operates according to certain biological principles and mechanisms not shared among other cognitive modules.[2] The human faculty is argued to consist of two primary modules: the cognitive component and the performance components. The former is a repository of information that is made accessible to the conceptual-intentional (C-I) and the articulatory-perceptual (A-P) external interfaces of the performance components. The information flow between the cognitive and performance modules is made possible via two levels of linguistic representation, the level of Logical Form (LF) at the C-I interface, and the level of Phonological Form (PF) at the A-P interface.

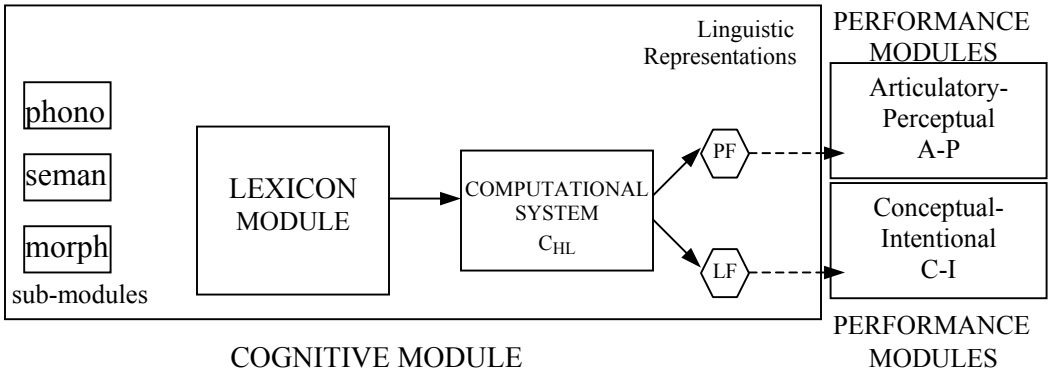

Figure 1. Human Language Faculty

We understand the cognitive system to consist of two general sub-modules: a computational system (C_{HL}) and a lexicon.[3] In its final (steady) state, the lexicon module operates by mapping completely specified lexical items to be selected by the C_{HL} in order to

[2] We will adhere to this view of the monolithic language faculty for the moment, but are aware that there are other more interactive instantiations to discuss as well.
[3] We follow Fodor (1983), Chomsky (1995), and Pinker (1995) in positing that the lexicon is a component of the language faculty; however, it is functionally separable and mediated by distinct cognitive and computational mechanisms than the modules of grammatical knowledge.

generate full derivations. Within current Chomskian (1995, 1998, 2000) formulations, the lexicon is posited as the "optimal encoding" of lexical idiosyncrasies, such that it provides only that information that is sufficient for building a phonological-semantic representation at the PF and LF interfaces. The lexicon itself excludes language-specific aspects of phonology and morphology, along with any principles deemed predictable per UG. As such, the lexicon module is interpreted as the site of parametric variation, where options and alternatives not otherwise predictable are specified for the speaker. The linguistic data housed in the lexicon originate in three formal sub-modules: phonological, semantic and morpho-syntactic.

1.3. THE REPRESENTATION OF THE INITIAL STATE

In terms of the initial (pre-linguistic) state of the language faculty, we will also assume without further discussion that beyond the two primary modules, the human language faculty minimally is equipped with a Language Acquisition Device (LAD), including innately-specified Universal Grammar (UG) principles. The child's capacity to acquire linguistic knowledge is often conceptually framed in terms of UG, a component of the human language faculty mediated by a set of invariant principles common to all human languages. These principles are further delimited by a finite set of options, or parameters, which are proposed to constrain the variation found among languages in far-reaching ways Chomsky (1981, 1986a, 1988, among others).

Based on our proposed working definition of 'linguistic system,' we posit that, unlike UG principles, it is the LAD features that have a suitably rich enough capacity to transmit information between modules and sub-modules, linking them in a type of network[4]. We thus assert that a fully operative linguistic system arises from the cognitive module only when there is intercommunication established between each of the sub-modules, such that there is the ability to

[4] Cf. 'correspondence rules' in Jackendoff (1997, 2002)

generate complete sound-meaning pairs (henceforth full derivations). Prior to the emergence of full derivational capacity, we argue that there is no linguistic system, *per se*. Incomplete derivations are still possible at various stages, within the confines of the highly delimited set of universal principles and local conditions of UG presiding within each module. As the language faculty matures, the PF and LF interfaces provide increasingly more specific instructions for the C-I and A-P performance components, respectively. We take up the details of this point shortly.

While LAD or UG components are often attributed with extensive powers for child linguistic development, accounts often leave important developmental questions unasked: (i) what explains learner progress from stage to stage? (ii) how exactly do monolingual and multilingual learners implement the innate principles and parameters of language? One standard response---that we use general cognitive capacities, rather than a human language faculty/LAD, may be called increasingly into question, due to the nature of linguistic ability which can be shown to be independent of certain developmental milestones or neurological conditions. And if, as appears to be the case, the properties of language apply exclusively in a rather limited domain, it is reasonable to propose that this specific innate capacity is configured, at least to a degree (cf. Fodor 1983:37), as an architectural module.

1.4. MODULARITY OF LANGUAGE

As the notion of modularity has received ample treatment in the psycholinguistic and cognitive science literature, we present only the briefest outline here.[5] The underlying premise of modularity is that of a network of constraints on the flow of data. Certainly, many mental phenomena, such as motor control or the organization of the visual field are treated as involving

[5] For an in-depth discussion of modularity, see Fodor (1983). For summaries of the language faculty, consult Chomsky 1995, Jackendoff 1997.

part-whole hierarchical relations (per Jackendoff 1977:10), so it is not unreasonable to conclude that language might follow a similar pattern. As concerns the human language faculty, modularity translates to specific subtasks related to language competence and performance vis-à-vis different specialized procedures. Given the general properties typically attributed to modular organization, the following cluster of characteristics emerges from the module architecture:

a) modules are domain specific: they operate only on specific classes of input, and their computations within each domain are autonomous
b) modules process automatically: their functions are involuntary
c) modules are extremely fast: the encapsulation of information (*e.g.*, access to only information represented within the local structures) enables parallelism
d) modules output is shallow or highly constrained: product of a given module must be further processed along a path

In short, we are assuming that in terms of language representation, the interfaces of linguistic modules and sub-modules function as grammatical information filters, which direct linguistic data in both one-way and two-way currents. Restriction of data flow occurs on various levels: first, a portion of the information found within an individual module is not available outside that module (inter-levels of modular processing). Likewise, a portion of the information outside a module may access the output information of a particular module, but extra-modular information is not available to the internal components of that module.

There are different degrees and classes of modularity. For instance, Fodor (1983) joins Chomsky (*e.g.,* 1981) in advocating an autonomous language faculty which operates according to biological principles and mechanisms not shared with other cognitive modules of the mind/brain.[6] By extension, the language faculty is itself presumed to be composed of a distributed, multi-level modular architecture, where the function of each unit is determined by representationally encapsulated, independent subsystems of linguistic theory. Fodor differs from

Chomsky in positing modularity specifically in terms of language processing, such that processing, as an input system, consists of modularized operations and constraints on the processing of linguistic information. Chomsky invokes modules in terms of distinguishing principles within syntactic theory, as a means to explain the organization of linguistic competence. From a formal linguistic standpoint, this "representational modularity (Jackendoff 1997, Crain & Wexler 1999:304)" has influenced current theoretical tendencies, as the various sub-components of syntax, semantics, phonology, morphology, etc., all make use of their own independent mechanisms. The fact that elements used to account for the well-formedness of possible syntactic structures are typically quite distinct from those employed for phonological phenomena, clearly motivates the modular notion of specialized units for specialized tasks. On an individual basis, the modules of grammar are relatively abstract and largely non-restrictive; however, given the appropriate interfacing between modules, we obtain a very rich linguistic system.

1.5. PRELIMINARY CONCLUSIONS: THE NATURE OF THE LINGUISTIC SYSTEM

We accept that a human language faculty, given its multi-functions, must be compatible with modular conceptions of both performance and competence functions. A second assumption we accept is that linguistic modularity obviates the need for complex general cognitive mechanisms: when there is no high-level interaction between distinct domains, a modularized architecture provides efficient and rapid processing of a wide variety of information, since the processing is distributed concurrently among the units without complex cognitive processes spanning dissimilar modules. While we posit, in agreement with Crain & Wexler (1999), that the presence of language modules is biologically indicated, their position is that adults and

[6] Although, certain broad variables such as attention, memory, etc. may be exploited across several cognitive

infants share “essentially” all of the same linguistic abilities and principles of the corresponding modules (1999:389). We do not subscribe to a Continuity view, as we support the notion of different modules surfacing at different stages of maturation, such that a system does not spring fully developed in the mind/brain of the newborn. Here, we define linguistic 'maturation' as synchronized organizing principles imposed on the learner's hypothesis space. These constraints could come in the form of linguistic instructions, leading the child to attend to certain data at a determined developmental stage. Felix (1992:48) points out that for reasons of parsimony and economy, it is plausible that UG would depend on an ordered acquisition of principles and parameters, as supplied through mechanisms of maturation. Specifically, the role of maturation in the sense outlined here is to determine which (sub-)module interacts with input data at a given time. Similarly, Pinker (1997:33) claims that linguistic modules are innately designed to mature internally, comparing the modular architecture to “several innate learning machines” able to acquire knowledge according to their own respective algorithms.

Simplified evidence supporting a maturation of language modules and their operations can also be enlisted in this argument: if a module for the lexicon is assumed to be projected, then one could be persuaded that the initial lexical component has no content, but must gradually derive information from the environment. Even if no case could be made for modular development that is triggered by the environment or comes online in some fashion, there is nothing in principle that bars mature-at-onset modules from undergoing further modifications. In the final analysis, the most accurate hypothesis could turn out to be a scenario where internal development within a given module proceeds via some growth schedule, while certain (perhaps all) constraints on data flow, (i.e., restrictions on processing data external or internal to the module) are non-maturationally in place.

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faculties.

In sum, to the degree that linguistic knowledge is made up of innately organized components, we hypothesize that such modules develop over time. The "core" system, therefore, is not in place until sufficient information has been integrated through functioning intra- and inter-level interface components for the modules. Along these lines, we make explicit our definition of linguistic *system* as knowledge systematically derived and represented in highly interactive modular (*i.e.,* mature) interfaces. We further expand on these issues below.

An operative linguistic system, however, must be also brought online by linguistic input. Unlike adults, the ability to construct full derivations in the child's language faculty depends on the acquisition of a range of lexical properties, ultimately feeding into the lexicon module. This necessary information can only be learned over time. As evidenced by linguistic development in children, up until the onset of a mature, systematized grammar, the child is merely stringing together a few words in a strict configurational template/pattern with many gaps (Deuchar & Quay 1998). We further expand on these issues below with our discussion of early bilingual capacity.

2.0 MODEL: PROCESSES LEADING TO THE EMERGENCE OF BILINGUAL SYSTEMS

Thus far we have suggested that it is necessary to assume a modular account of L1 acquisition. Within this framework, we now describe a conceptual model for the specific representational architecture and internal processing mechanisms that may underlie the bilingual's L1 acquisition task.

2.1. Internal Computations: The Development of Speaker Competence

The current model indirectly shares elements with an earlier monolingual proposal by Boser *et al.* (1999), in which the initial language architecture is presented as an autonomous module comprised of several dynamic sub-units set to unfold according to their respective developmental timetables and specialized linguistic functions. On our conception, the language faculty can be composed of three developmental tiers, each reflecting grammatical well-formedness at a given stage of bilingual development.

2.1.1 Pre-system Level One: Acquiring and organizing module contents

The first level operates on incoming data to accumulate lexical items, while also storing respective internal properties within the independent sub-modules of phonology, semantics, and morphosyntax. DISCUSS

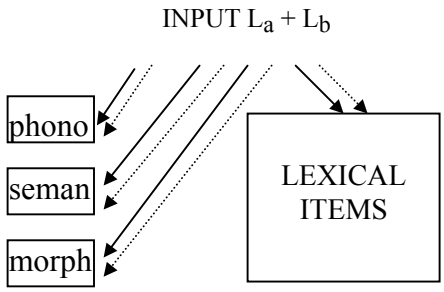

Figure 2. Level 1: Local Modules: Pre-system

If our hypothesis is correct, observable evidence supporting this first level should be found in a general lack of systematicity across and within approximately the first 15 months of early bilingual "grammars", due precisely to the absence of modular intercommunication and the small quantity of lexical forms.[7] Overall evidence: Navarro et al. (1998) suggest that both monolinguals and bilinguals at 2 years fail to produce a reliable inventory of language-specific

elements. Phonological evidence: Nicoladis & Genesee (1997) conclude that early phonological development in bilingual children could be interpreted as a "a universal pattern of acquisition" common to all language learners in early stages of development, after which specific patterns come for the different languages. Stager & Werker (1997) observe inconsistency of phonetic detail in early word production of infants aged 14 months and postulate that in speech perception and word comprehension there are signs of functional reorganizations. The phonological production of M. (age 1;10) showed that phones common to both Spanish and English were acquired prior to sounds specific to either language, per Deuchar & Quay (2000). Pearson et al. (1995) likewise indicate that language-particular segments do not appear in critical enough amounts to posit the existence of two grammars in early data of Spanish-English infants, although later corpora do exhibit such specific elements. Morphosyntactic evidence: a formidable shortcoming of many of the recent morphosyntactic studies is the paucity of data charting infants age pre-1;5. Lexical evidence: More evidence in the production of lexical items could come from data indicating that children possess translation equivalents (words from each language with the same conceptual referent). Vihman (1985) reports 10% of translation equivalents at 1;2, while Quay (1995) observes the use of translation equivalents in her subject from the onset of speech, reaching a 40% quota from 1;5 to 1;10. Lanvers (1999) interprets the appropriate use of equivalents as evidence of emerging lexical separation approximately at the age of 1;6. Nicoladis & Genesee (1997) sustain that if a period exists in which the child does not distinguish words belonging to two different languages, it only occurs extremely early in the development, until the child acquires approximately 50 words. Semantic evidence: Jusczyk's (1997) studies show that by 10 months, children recognized for the first time weak-strong forms.

[7] Examples will be provided excerpted from the literature and from an original longitudinal study of four bilingual children aged 1;10 to 3;0 (Carla, Alberto, John and Joe) acquiring English and Spanish at home, based on parental

A month later they seem to listen to words for the first time as potential sources of semantic content, as results from Hallé & de Boysson-Bardies (1996) indicate. Werker et al. (1998) observed that at 1;2 infants seem to extract words from the speech stream, to recognize previously heard word forms, to associate words with objects and to understand the meaning of some words. By 15 months of age, children seem to process known and unknown words differently.

2.1.2. System Emergence Level Two: Communication between modules

Emerging from this initial tier is a second level. This tier regulates the gradual integration of information between the cognitive modules, ultimately providing complete and well-formed lexical candidates. At that point, the C_{HL} comes online to begin to map basic sound-meaning pairs into linear structures to send as LF-PF representations to the performance modules. It is at this intermediate level where an early bilingual grammar may be said to best embody the maturational representation put forth in the current modular hypothesis. During approximately 15-24 months of age, children experience a rapid growth in their vocabulary. If, as we posit, there is an ever-growing interaction between modules, we would expect to find an incremental integration of grammatical and lexical components, at times in the absence of strict language-specific production. Production data across various studies illustrate that both monolingual and bilingual children between 18-20 months of age begin to create utterances in which they appear to have a mastery of certain phonological, syntactic, and semantic aspects of their target grammar(s). However, they still retain many non-adult elements which, while not outside of the range of UG possibilities, are not within the limits of the language elicited. Syntactic evidence: Examining data of two-word utterances (1;7-1;9) Deuchar & Quay (1998) find evidence for the existence of a single rudimentary grammar (predicate-argument), which is common to the

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naturalistic recordings.

Spanish and English constructions in their subject. Based on bilingual infant corpora, Meisel (1989) first proposed that when children begin to employ syntactic mechanisms of expression, they are capable of discriminating between two systems. That is, from about age 1;11 onwards, the child is presumed to produce the target word order, appropriate verb-agreement morphology, and use of overt subjects.[8] Works by Lanza (1997) and Klausen et al. (1993), however, attest to morphological mixing and an occurrence of interchangeable inflection-markers in bilingual child speech still present just before age 2;0. Phonological evidence: Upon close examination of the Hildegard (Leopold 1939, 1947, 1949a and b) data ages 1;6- 2;0, Paradis (1996) concludes that the child did not necessarily possess systematized prosodic structures, despite the appearance of some language-specific segments in certain lexical items. Semantic evidence: Werker et al. (1998) observed that infants have a referential understanding of word meaning at about 20 months of age.

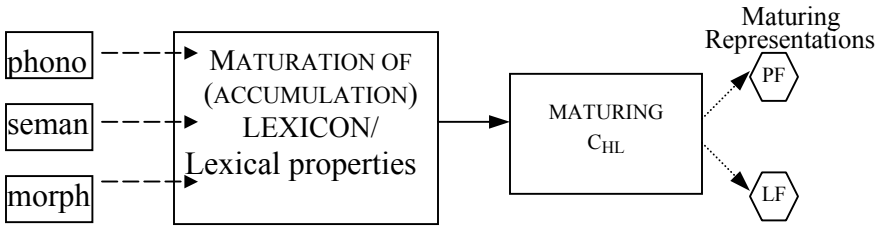

Figure 3. Integration

Given continued growth of each module at its pace in stage two, the properties gleaned from lexical learning are more complex and abundant, and set the stage for parameter-setting to occur. As mentioned earlier, it is the parameter-fixing process that organizes certain aspects of

[8] See, for instance, Meisel (1989, 2000).

the two grammars into separate language-specific components.[9] Whether the primary linguistic input consists of one grammar or two initially makes no difference to the language faculty and the mechanisms at work. Regardless, Level one characterizes an initial phase of language acquisition whereby the procedure of first organizing information according to the timetable of distinct modules is carried out. Level two demonstrates how the autonomous modules as constrained by UG gradually come to interact, endowing the child with increased grammatical capacities. This said, the LAD can be shown to be extremely sensitive to salient and/or consistent linguistic input. Thus, the degree of parametric variation that must be set in the lexicon is really the only respect that differentiates the simultaneous acquisition of two languages from that of monolingual acquisition. As information is amassed, the C_{HL} is able to access an even larger amount of linguistic expressions from the maturing lexicon module.

2.1.3. Fine-tuning Level Three: Developing general and language-specific systems

Level three illustrates that a general system emerges when it becomes possible to pinpoint strong coordination between modules. However, a language-specific system comes online only <u>after</u> parameters have been fixed into taken place. Until specific systems are in place via parameterization, we predict that certain types of sporadic interface constructions will continue to be evidenced in child bilingual speech.

[9] For a detailed model of bilingual parameter-setting, see Satterfield 1999.

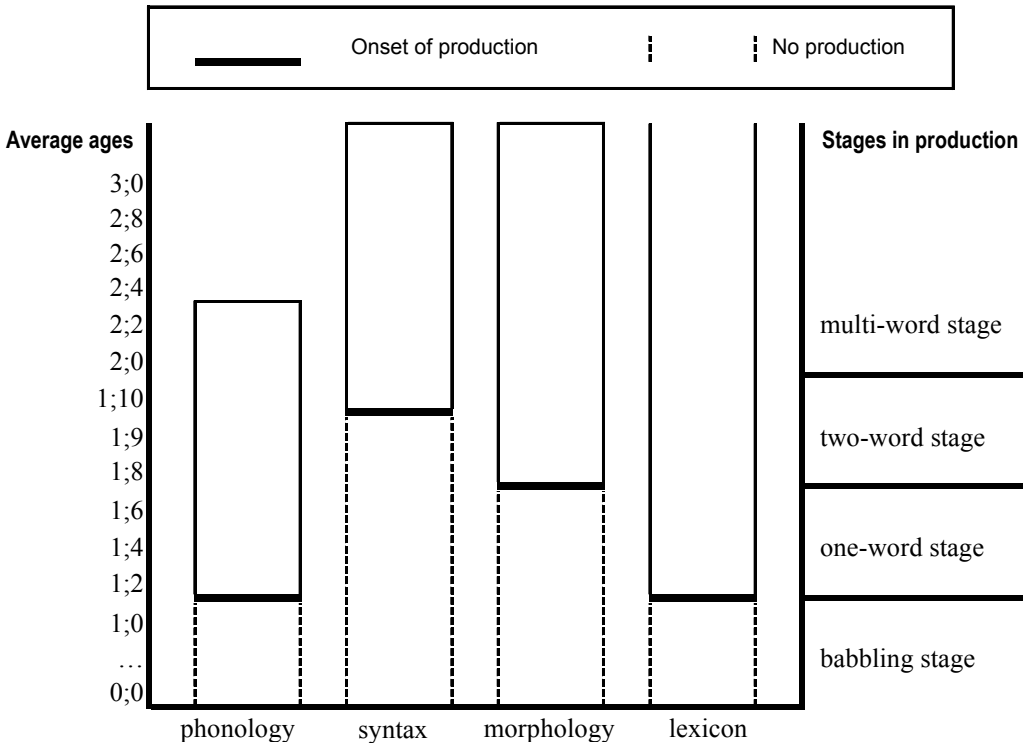

Figure 4. Comparison of development of linguistic modules in bilingual language acquisition

Level Three development along these lines can be observed in several studies. Phonological evidence: Recent research shows phonological differentiation in consonant production in bilinguals acquiring English and Spanish emerging at 2;3 (Schnitzer & Krasinski 1994 and Deuchar & Clark 1996). The latter study puts forth evidence that there is no consistent difference in the VOT of the stop consonants until the 2;3 age. Morphosyntactic evidence: although Deuchar & Quay (1998) report morphological variation, it is not until the multi-word stage that distinct grammatical structures are visible for each language, coinciding with the emergence of functional categories (Meisel 1989).

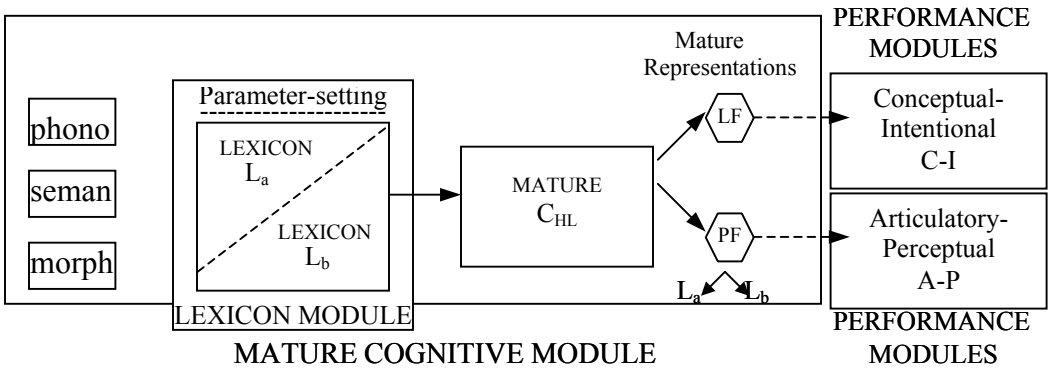

Figure 5. Bilingual System

2.2 Development of speaker performance (perception and production)

We view competence and performance as modules having interlocking characteristics, based on a definite set of assumptions (Chomsky 1965, 1995). In this view, if one hopes to gain insight into the performance system, it is instructive to examine specific grammatical modules. While we will not provide in-depth treatment of the underlying bilingual performance module, we assume that it is influenced by linguistic knowledge as well as by non-linguistic factors, accessed throughout language processing operations (Paivio & Begg 1981, Grosjean 2001). In the hierarchy of development, the output is made available to online interface performance or processor features, and can be transferred to the next level for subsequent analysis. Given the dynamic nature of these operations, we align ourselves with work by Dufour & Kroll (1995) who demonstrate that information processing strategies are asymmetrically utilized at different phases of bilingual proficiency. To this end, grammatical representations and parsing/processing must be so incorporated at every level of linguistic development, as the nature of competence is only visible by examining performance aspects.

4.0 CONCLUDING REMARKS

We have found strong reasons to posit that development necessarily must first be considered as it unfolds independently within each discrete linguistic module. Along these lines, we have tried to illustrate that the earliest grammars do not exhibit the same underlying integrated tendencies at the onset as those found in mature, fully systematized grammars. We likewise showed that to precisely account for the bilingual language acquisition operation, each module must have its own internal timetable that comes 'on-line' based on constrained input and maturational factors. We also introduced a three-tier learning theory that characterizes modular activity at the macro-level as a singular developmental architecture, with internally differentiated grammatical representations and superficially separate linguistic behaviors at the micro-level. As developmental findings suggest, this type of model may successfully capture various stages of the maturing linguistic competence and the processing strategies of the bilingual state. The model provided is able to construct intermediate representations that appear to simplify the bilingual learning task. Level one characterizes an initial phase of language acquisition whereby children simplify the linguistic problem by developing respective modules independently, in ways that correspond to the child's limited resources, such as memory (Newport 1988, 1990). Level two demonstrates how the autonomous modules (always constrained by UG) gradually come to interact, endowing the child with increased grammatical capacities. Level three illustrates that a language-specific system comes online only at a point when parameters are fixed. Until a specific system is in place, we predict that certain types of sporadic interface and mixed constructions will be evidenced in child bilingual speech.

Our hypothesized representational architecture is motivated in part by current theoretical linguistic formulations and empirical findings, but also by results of recent neurolinguistic

studies concerning bilingual language organization (cf. Hamers & Blanc 2000). Experimental works have begun to demonstrate that a speaker with two different grammars utilizes independent storage mechanisms for certain aspects of lexical and grammatical knowledge, but joint mechanisms for others. Moreover, it may be the case, as discussed in Opoku (1983) that the representational system varies according to the linguistic and social experiences of the speaker and his language(s) over time, such that a range of organizational schemas are adopted throughout the course of language development and use for a given individual.

A model of bilingual language development such as the one presented in this paper can assist enormously in approaching the task of observing the patterns of language acquisition in bilingual infants. Considering that each module is independent in its development sets a starting point to examine the issue under a different light. On the precursory assumption that the modular characterization captures an important property of early linguistic representation─one that is absent in instantiations of Fused- or Separate-System Hypotheses─we put forth a baseline definition of *language development* as **the systematic specialization and principled integration of an extant compartmentalized language faculty.** If this definition were widely deployed, the Unitary Hypothesis could be hospitably re-interpreted as positing a 'growing' architecture; one that develops all modules from an innately specified ground zero, and then subsequently organizes language specific features. Dual System accounts could consequently be seen as less growth-based and more static, given specialized organization commencing from the start of acquisition. One interesting aspect of our proposed definition is that it does not distinguish between these contrasting approaches as much as it shows that they can be intrinsically linked. For this reason, we argue that neither the one-nor two-system discussion will derive firm empirical conclusions. By employing the modular account, bilingual language

development can be grounded in a dynamic single system at the macro-level while still sustaining the aspects of differentiation found in dual systems at the micro-level.

Insofar as psycholinguistic research suggests that linguistic knowledge is encapsulated in autonomously functioning units, it still remains to concretely demonstrate why a modular account might be more acceptable to bilingual acquisition than either the standard one-or two-system approach. We therefore attempt to determine the feasibility of each hypothesis, rigorously considering any counterfactual implications that may emerge.

Let us first revisit assumptions grounding the respective One-and-Two Systems approaches. Proponents of the Unitary System appeal to the hypothesis that language-mixing in the earliest months of speech is the developmental outcome of a fused lexical system. The claim is that linguistic resources are highly variable at this stage, such that bilingual children possess no translation equivalents in their early lexicon. Thus, strategies sympathetic to a single system analysis inherently imply that initial vocabulary items from both languages are not distinguished across any contexts, and are contained in a shared lexicon until the faculty shows greater maturation effects.

Motivating the non-separated status of early languages on the basis of frequent language-mixing proves to be a difficult task. A methodical strategy to establish the existence of a one-system grammar is advanced by Schnitzer & Krasinki (1994). We paraphrase their phonology-centered criteria: a) failure to use sounds which occur in only one of the two languages; b) in the context of lexicon L_a , use of sounds not acceptable in L_a, but acceptable in L_b; and c) in the context of L_b, use of allophones in sites permissible in L_a, but not permissible in L_b. Genesee (1989) and others have observed, however, that bilingual infants do not use both languages indiscriminately across all contexts. Further, to the small degree that mixing is present, the latter

authors state that children may mix due to reasons ranging from lack of competence in one of the grammars, to adherence to caregiver mixed speech, or even for pragmatic effect. Thus, a general contention seems to be that language-mixing does not to reflect a fused system.

Problematically for its opponents, there is at least one reason for not rejecting the Single-System hypothesis out of hand. If a "truly" mixed bilingual system must exhibit differences not found in the relevant adult system given the same context, then we must also reconcile why very young monolingual children at the early stages of acquisition have grammatical rules with no basis in the language being acquired. For instance, children in American English-speaking environments are attested to omit subject pronouns in tensed clauses (cf. Hyams 1986), and exhibit an extra *wh*-expression in long distance questions (*e.g.,* What do you think *what* pigs eat? (Crain & Thorton 1998)). This child's structure is at odds with adult English, which contains no such features. Moreover, it would be computationally "easier" to simply have a zero or deleted Complementizer in this site, rather than the *wh*-word. These tokens beg the question of why monolingual children with arguably simple "single-systems" should exhibit such mixing tendencies, whereas their bilingual counterparts would maintain strict separations across grammars. As we claim, such evidence is more likely to indicate that early developmental stages in general are susceptible to broad manipulations of certain GSG elements which, while compatible with over-arching UG principles, are not observed in the child's later parameterized, language-specific grammar.

In terms of the Dual-System hypothesis, one expects to find that differentiation occurs early on for the bilingual child. The appearance of translation equivalents is employed to support the notion of independent language systems. Below, an example from Pérez-Bazán (in

preparation) where an infant in a Spanish-English environment (1;8) epitomizes the overt use of translation equivalents:

1) The mother asks questions and the child gives answers:

Mother: how old are you?
Alberto: one
Mother: ¿cuántos años tienes?
Alberto: uno

Thus, if the child can access equivalent terms, they then enter into a language choice situation, even though their differentiated bilingual systems may not have the pragmatic resources needed to make appropriate discourse choices. With the two-system hypothesis, there is the tacit implication that linguistic resources are more static, presumably maturing or coming online almost immediately into acquisition. [10]

As illustrated by Pérez-Bazán (among others), evidence indicating that children possess early translation equivalents does surface. Vihman (1985) reports 10% of translation equivalents at 1;2, while Quay (1995) observes the use of translation equivalents in her subject from the onset of speech, reaching a 40% quota from 1;5 to 1;10. Lanvers (1999) interprets the appropriate use of equivalents as evidence of emerging lexical separation approximately at the age of 1;6.

The Separate Systems hypothesis appears to be on stronger footing, if only from a conceptual viewpoint. Yet, to the extent that differentiation can be equated with the "ability to use different grammatical means for expressing similar/identical semantic functions in both languages (Meisel 1989/2000:346)," one hopes for more straightforward answers. Instead, the problematic issue for these researchers remains the "how" and the "when" of this process. True

enough, the lack of very early infant bilingual data both in terms of breadth and depth, render it nearly impossible to determine at what stage two systems become clearly apparent. The broadest and the most recent studies (Meisel 1994b, Deuchar & Quay 2000, Pérez-Bazán (in preparation) tend to lean in the direction of children sharing rudimentary constructions across languages prior to age 2;0, with language-specific utterances that are *consistently* produced shortly after that point.

Our intent in discussing the hypotheses of one-two systems in this vein is to reveal certain inconsistencies in these approaches, rather than to imply that a dichotomous relationship exists. As we have previously demonstrated, the distinction between Single and Dual System architectures as advanced in the literature is not necessarily a rigorous one. Moreover, given a principled definition of "system," aspects of both accounts can be effectively subsumed under a modularity approach.

In any case, it is our view that the pivotal factor distinguishing the current modular proposal from these approaches may be uncovered by determining the nature of the bilingual system. Our method leans toward the observation of gradual systematicity, as manifested via intermediate representations of modular concatenations. Suppose that language growth takes place on distinct timetables depending on the aspect of grammar being investigated. Then, at the very early stages of bilingual acquisition, a young child's immature "grammars" are not predicted to be wildly irregular; but rather, to be unsystematic in terms of a full-integration of modular data. Such characteristics are identified namely in the sense that they do not appear to derive from adult-like linguistic- and/or social communicative classifications. We claim that such

[10] Nicoladis & Genesee (1997) sustain that if a period exists in which the child does not distinguish words belonging to two different languages, it only occurs extremely early in the development, until the child acquires approximately 50 words.

states point to the absence of (a) *fully*-functional dual or singular linguistic system(s). We now provide further justification for the modularity-based model.

The question is no longer one of whether the child starts with a unitary system (Volterra & Taeschner 1978) or two separate systems (DeHouwer 1990, Genessee 1989, etc.). Indeed, this query to date has resulted in inconclusive and unsatisfactory answers---but rather, the more relevant question becomes: at what stage in the development each of the modules has sufficient maturation occurred to provide a representation of the bilingual's linguistic competence?

REFERENCES

Bates, E., P.S. Dale, & D. Thal. (1995). Individual differences and its implications for theories of language development. In P. Fletcher & B. MacWhinney, (eds.), T*he Handbook of Child Language,* pp. 96-151. Cambridge, MA: Blackwell.

Bialystok, E., (ed.) (1991). *Language Processing in Bilingual Children.* Cambridge: Cambridge University Press.

Bosch, L. & Sebastian-Galles, N. (1997). Native language recognition abilities in 4-month-old infants from monolingual and bilingual environments. *Cognition* 65, 33-69.

Chee, M., Soon, C. & H. Lee. (ms., to appear 2002). *Common and segregated neuronal networks for different languages revealed unsing functional magnetic resonance adaptation*. Journal of Cognitive Neuroscience.

Chomsky, N. (1995). *The minimalist program.* Cambridge, MA: MIT Press.

Chomsky, N. (1988). *Language and problems of knowledge: The Managua Lectures.* Cambridge, MA: MIT Press.

Chomsky, N. (1986a). *Knowledge of language: its nature, origin, and use.* New York: Praeger.

Chomsky, N. (1981). *Lectures on government and binding.* Dordrecht: Foris.

Chomksy, N. (1965). *Aspects of the Theory of Syntax.* Cambridge, MA: MIT Press.

Crain, S. & K. Wexler. (1999). A modular approach to methodology. In W. Ritchie & T. Bhatia (eds.), *Handbook of Child Language Acquisition,* pp. 387-425. London: Academic Press.

Crain, S. & R. Thorton. (1998). *Investigations in Universal Grammar.* Cambridge, MA: MIT Press.

Crain, S. & M. Steedman.(1985). On not being Led Up the Garden Path: The Use of Context by the Psychological Syntax Processor. In D.R. Dowty, L. Karttunen, & A.M Zwicky (eds.), *Natural Language Parsing*, pp. 320-358. Cambridge: Cambridge University Press.

Cristophe, A. Dupoux, E., Bertoncini, J. & Mehler, J. (1994). Do infants perceive word boundaries? An empirical approach to the bootstrapping problem for lexical acquisition. *Journal Acoustical Society of America* 95, 1570-80.

Crocker, M. (1996). *Computational Psycholinguistics: An Interdisciplinary Approach to the Study of Language.* Dordrecht: Kluwer.

Cruttenden, A. (1981). Item-learning and system learning. *Journal of Psycholinguistic Research,* 10: 79-88.

de Boysson-Bardies, B. & Vihman, M. (1991). Adaptation to language: Evidence from babbling and first words in two languages. *Language* 67, 297-319.

DeHouwer, A. (1995). Bilingual language acquisition. In P. Fletcher & B. MacWhinney (eds.), The *Handbook of Child Language*, pp. 219-250. Oxford: Blackwell.

De Houwer, A. (1990). *The acquisition of two languages from birth: a case study*. Cambridge, UK Cambridge University Press.

Deuchar, M. & S. Quay. (2000). *Bilingual Acquisition: Theoretical implications of a case study.* Oxford: Oxford University Press.

Deuchar, M. & S. Quay. (1998). One vs. two systems in early bilingual syntax: Two versions of the question. *Bilingualism: Language and cognition* 1(3), 231-243.

Deuchar, M. & Clark, A. (1996). Early acquisition of the voicing contrast in English and Spanish. *Journal of Phonetics* 24, 351-365.

Devilliers, J. (2001). Continuity and modularity in language acquisition and research. *Annual Review of Language Acquisition 1*, 1-64.

Dufour, R. & J. Kroll. (1995). Matching words to concepts in two languages: A test of the concept mediation model of bilingual representation. *Memory and Cognition* 23, 66-80.

Fantini, A. (1985). *The Language Acquisition of a Bilingual Child*. Clevedon: Multilingual Matters.

Felix, S. (1992). Language acquisition as a maturational process. In J. Weissenborn, H. Goodluck, & T. Roeper (eds.), *Theoretical Issues in Language Acquisition: continuity and change in development*, pp.25-52. Hillsdale, NJ: Lawrence Erlbaum.

Fodor, J.A. (1983). *The modularity of mind*: *an essay on faculty psychology.* Cambridge, MA: MIT Press.

Frazier, L. (1984). Modularity and the Representational Hypothesis. In *Proceedings of NELS 15*, pp. 131-144. Brown University, Providence, Rhode Island.

Garfield, J. (1989). *Modularity in Knowledge-Representatioon and Natural Language Understanding.* Cambridge, MA: MIT Press.

Genesee, F. (2001). Bilingual First Language Acquisition: Exploring the limits of the language faculty. In M. McGroarty (ed), *Annual Review of Applied Linguistics: Language and Psychology 21*, 153-168. Cambridge: Cambridge University Press.

Genesee, F. (2000). Early Bilingual Language Development: One Language or Two? In L. Wei (ed), *The Bilingualism Reader*, pp. 327-343. London: Routledge.

Genesee, F. (1989). Early Bilingual Language Development: One Language or Two? *Journal of Child Language* 16, 1, 161-179.

Grosjean, F. (2001). The bilingual's language modes. In J. Nicol (ed.), *One Mind, Two Languages: Bilingual Language Processing*, Chapter 1. Oxford: Blackwell.

Grosjean, F. (1998). Studying bilinguals: Methodological and conceptual issues. *Bilingualism: Language and Cognition*1, 131-149.

Hallé, P.A. & de Boysson-Bardies, B.(1996). The format of representation of recognized words in infants' early receptive lexicon. *Infant Behavioral Development* 19, 463-481.

Hoffman, C. 1991. *An introduction to Bilingualism*. Longman linguistics library. New York: Longman.

Hyams, N. (1986). *Language acquisition and the theory of parameters.* Dordrecht: Reidel.

Jackendoff, R. (2002). *Foundations of Language*. Oxford: Oxford University Press.

Jackendoff. R. (1997). *The Architecture of the Language Faculty.* Cambridge, MA: MIT Press.

Jackendoff, R. (1992a). *Languages of the mind*. Cambridge, MA: MIT Press.

Johnson, C. & P. Lancaster. (1998). The development of more than one phonology: a case study of a Norwegian-English bilingual child. *International Journal of Bilingualism* 213, 265-300.

Jusczyk, P.W. (1997). *The Discovery of Spoken Language*. Cambridge, MA: MIT Press.

Juczyk, P.W. & Hohne, E.A. (1997). Infant's memory for spoken words. *Child Development* 64, 675-687.

Klausen, T. Subritzky, M., & M. Hayashi. (1993). Initial production of inflections in bilingual children. In G. Turner & D. Messers (eds.), *Critical influences on child language acquisition and development*, pp.65-92. London: Macmillan.

Lanvers, U.(1999). Lexical growth patterns in a bilingual infant: The occurrence and significance of equivalents in the bilingual lexicon. *International Journal of Bilingual Education and Bilingualism* 2 (1), 30-52.

Lanza, L. (1997). *Language Mixing in Infant Bilingualism: A Sociolinguistic Perspective.* Oxford: Clarendon Press.

Leopold, W.F. (1939-1949). *Speech Development of a Bilingual Child: a linguist's record*. 4 Volumes. New York: AMS Press.

Levy, Y. (1994). Modularity Reconsidered. In Y. Levy, (ed). *Other Children, Other Languages: Issues in the Theory of Language Acquisition,* pp.383-400. Hillsdale, NJ: Lawrence Erlbaum.

Lust, B, S. Flynn, C. Foley, & Y. Chien. (1999). How Do We Know What Children Know? Problems and Advances in Establishing Scientific Methods for the Study of Language Acquisition and Linguistic Theory. In W. Ritchie & T. Bhatia (eds.), *Handbook of Child Language Acquisition,* pp. 427-456. London: Academic Press.

Mandel, D.L., Juczyk, P.W. & Pisoni, D.B. (1995). Infants' recognition of the sound patterns of their own names. *Psychological Science* 6 (5), 315-318.

Marr, D. 1982.

Mehler, J., Juczyk, P.W., Lambertz, G., Halsted, N., Betoncini, J. et al. (1988). A precursor of language acquisition in young infants. *Cognition* 29, 144-178.

Meisel, J.M. (2000). Early differentiation of languages in bilingual children. In L. Wei (ed), *The Bilingualism Reader*, pp. 344-369. London: Routledge.

Meisel, J.M. (1994b). Codeswitching in young bilingual children. *Studies in Second Language Acquisition* 16, 413-439.

Meisel, J.M. (1990a). Grammatical development in simultaneous acquisition of two first languages. In J.M. Meisel (ed.), *Two first languages: Early grammatical development in bilingual children*, pp.5-22. Dordrecht: Foris.

Meisel, J. M. (1989). Early differentiation of languages in bilingual children. In Hyltenstam, K. & L. Obler (eds), *Bilingualism Across the Lifespan: aspects of acquisition, maturity and loss*, 13-40, Cambridge: Cambridge University Press, 13-40.

Meisel, J.M. (1986). Word order and case marking in early child language. Evidence from simultaneous acquisition of two first languages: French and German. *Linguistics* 24, 123-183.

Moon, C., Cooper, R.P., Fifeer, W.P. (1993). Two-day old infants prefer native language. *Infant Behavioral Development.* 16, 495-500.

Navarro, A., Pearson, B., Cobo-Lewis, A., & Oller, D. (1998). Identifying the language spoken by 26-month-old monolingual and bilingual learning babies in a no-context situation. In A. Greenhill, M. Hughes, H.Littlefield, and H.Walsh (eds.), *Proceedings of BUCLD 22*, pp. 557-568. Somerville, MA: Cascadilla Press.

Nazzi, T., J. Bertoncini, & J. Mehler. (1998). Language discrimination by newborns: towards an understanding of the role of rhythm. *Journal Experimental. Psychology*.

Newport, E. (1990). Maturational Constraints on Language Learning. *Cognitive Science* 14, 11-28.

Newport, E. (1988). Constraints on learning and their role in language acquisition: Studies of the acquisition of American Sign Language. *Language Sciences* 10, 147-172.

Nicoladis, E. & F. Genesee. (1997). Language development in Preschool Bilingual Children. *Journal of Speech-Language Pathology and Audiology* 21, 4, 258-270.

Padilla, A.M. & Liebman, E. 1975. Language acquisition in the bilingual child. *Bilingual Review* 2, 34-55.

Paivio, A. & I. Begg. (1981). *Psychology of Language*. Englewood Cliffs, NJ: Prentice-Hall.

Paradis, J. (1996). Phonological differentiation in a bilingual child: Hildegard revisted. In A. Stringfellow, D. Chana-Amitay, E. Hughes, & A. Zukowski (eds.), *Proceedings of BUCLD 20,* pp. 528-539. Somerville, MA: Cascadilla Press.

Paradis, M. (1985). On the representation of two languages in one brain. *Language Sciences* 61, 1-39.

Pearson, B., S. Fernández, & D. Oller. (1995). Cross-language synonyms in the lexicons of bilingual infants: one language or two? *Journal of Child Language* 22, 345-368.

Pérez-Bazán, M.J. (in preparation). Aspects of Language Choice in Bilingual Infants. Ms., University of Michigan.

Peters, A. (1986). Early Syntax. In P. Fletcher & M. Garman (eds.), *Language Acquisition 2nd Edition*, pp.307-325. Cambridge: Cambridge University Press.

Pinker, S. (1997). *How the mind works*. New York: Norton.

Pinker, S. (1995). Why the Child Holded the Baby Rabbits: A Case Study in Language Acquisition. In L. Gleitman & M. Liberman (eds.), *An Invitation to Cognitive Science, Volume One: Language*, pp. 199-241. Cambridge, MA: MIT Press.

Quay, S. (1995). The bilingual lexicon: implications for studies of language choice. *Journal of Child Language*, 22, 369-387.

Saleemi, A. (to appear). Syntax Learnability: the problem that won't go away. Ms, National University of Singapore.

Satterfield, T. (1999). *Bilingual Selection of Syntactic Knowledge:Extending the Principles and Parameters approach.* Dordrecht: Kluwer.

Schlesinger, I. (1982). *Steps to Language*. Hillsdale, NJ: Lawrence Erlbaum.

Schnitzer, M.L. & Krasinski, E. (1994). The development of segmental phonological production in a bilingual child. *Journal of Child Language* 21, 585-622.

Slobin, D. (1985a). Why study acquisition crosslinguistically? In D. Slobin (ed.), *The crosslinguistic study of language acquisition: the data*. Hillsdale, NJ: Lawrence Erlbaum.

Stager, C.L. & Werker, J.F. (1997). Infants listen for more phonetic detail in speech perception than in word learning tasks. *Nature* 388, 381-382.

Swain, M. (1972). Bilingualism as a first language. Ph.D. dissertation, University of California at Irvine.

Vihman, M. M. (1982). The acquisition of morphology by a bilingual child. *Applied Psycholinguistics* 3, 141-160.

Vihman, M. M. (1985). Language differentiation by the bilingual infant. *Journal of Child Language*, 12, 297-324.

Vihman, M. M. (1986). More on language differentiation. *Journal of Child Language*, 13, 595-597.

Volterra, V. & Taeschner, T. (1978). The acquisition of language by bilingual children. *Journal of Child Language* 5, 2, 311-326.

Werker, J.F., Shi, R., Desjardins, R , Pegg, J.E., Polka, L. et al. (1998). Three methods for testing infant speech perception. In *Perceptual Development: Visual, Auditory, and Speech Perception in Infancy*, ed. Broe, M. & J. Peirre-Humbert. Cambridge, UK: Cambridge University Press.

Werker, J. F. & Tees, R. C. 1999. Influences on infant speech processing: toward a new synthesis. *Annual Review of Psychology.* 50, 509-535.

Wexler, K. (1999). Maturation and Growth of Grammar. In W. Ritchie & T. Bhatia (eds.), *Handbook of Child Language Acquisition*, pp. 55-110. London: Academic Press.

Wexler, K. (1990a). Innateness and maturation in linguistic development. *Developmental Psychobiology* 23(3):645-660.

Yamada, J. (1990). *Laura: A case for the modularity of language.* Cambridge, MA: Bradford Books.